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United States Patent

Wong et al.

(10) Patent No.:

US 9,287,915 B2

(45) Date of Patent:

*Mar. 15, 2016

(54)

RADIATION REDIRECTING ELEMENTS FOR PORTABLE COMMUNICATION DEVICE

(71)

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Notice:

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21)

Appl. No.:

14/297,162

(22)

Filed:

Jun. 5, 2014

(65)

Prior Publication Data

US 2014/0287697 A1 Sep. 25, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/894,039, filed on May 14, 2013, now Pat. No. 8,750,948, which is a continuation of application No. 13/491,747, filed on Jun. 6, 2012, now Pat. No. 8,442,602, which is a

(Continued)

(51)

Int. Cl.

H04B 1/38 (2015.01)

H04B 1/3827 (2015.01)

(Continued)

(52)

U.S. Cl.

CPC H04B 1/3838 (2013.01); H01Q 1/243 (2013.01); H01Q 1/245 (2013.01); H01Q 1/48 (2013.01);

(Continued)

(58)

Field of Classification Search

CPC H01Q 1/521; H01Q 1/40

USPC 455/73, 575.5

See application file for complete search history.

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Primary Examiner — Ayodeji Ayotunde

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ABSTRACT

An antenna or set of antennae for a wireless device is provided by embedding the antennae into the battery case or generally the surface area of a wireless phone. The antenna connections are through the battery's connections to the wireless device. The antenna can be located at the back surface of the battery or the rear surface of a wireless phone, facing away from the user. An RF shielding device can be embedded into the battery and configured in relation to the antenna such that the RF field intensity and the consequent specific absorption rate for the user is lowered while the outgoing signals of the wireless device remain fully adequate for the function of the wireless device. This feature is preserved for a multi-band operation because a digital phase shifter is used between two radiating antennae. An external case is used as a complement to the wireless phone.

20 Claims, 13 Drawing Sheets

The diagram illustrates a cross-sectional view of an antenna system integrated into a portable communication device, specifically an iPhone. The device is shown with a width of 62.5 mm. The antenna system consists of several director elements (deirector1 through deirector5) and a loop. The dimensions of the components are as follows:

- deirector5: 7 mm wide, 50 mm long, 1.4 mm thick.
- deirector4: 7 mm wide, 50 mm long, 1.5 mm thick.
- deirector3: 7 mm wide, 50 mm long, 1.5 mm thick.
- deirector2: 7 mm wide, 50 mm long, 1.5 mm thick.
- deirector1: 7 mm wide, 50 mm long, 1.7 mm thick.
- Loop: 5.8 mm wide, 17 mm high (when flat), 3 mm thick.
- The system is suspended 1 mm away from the iPhone case.
- The loop is curved, but 17 mm is the dimension when flat.

Related U.S. Application Data

continuation of application No. 12/614,132, filed on Nov. 6, 2009, now Pat. No. 8,208,980.

- (60) Provisional application No. 61/112,141, filed on Nov. 6, 2008, provisional application No. 61/158,551, filed on Mar. 9, 2009.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 9/04 (2006.01)

H01Q 15/14 (2006.01)

H04B 1/3883 (2015.01)

H05K 9/00 (2006.01)

H01Q 5/371 (2015.01)

(52) **U.S. Cl.**

CPC *H01Q 5/371* (2015.01); *H01Q 9/0407* (2013.01); *H01Q 15/14* (2013.01); *H04B 1/3883* (2013.01); *H05K 9/0056* (2013.01)

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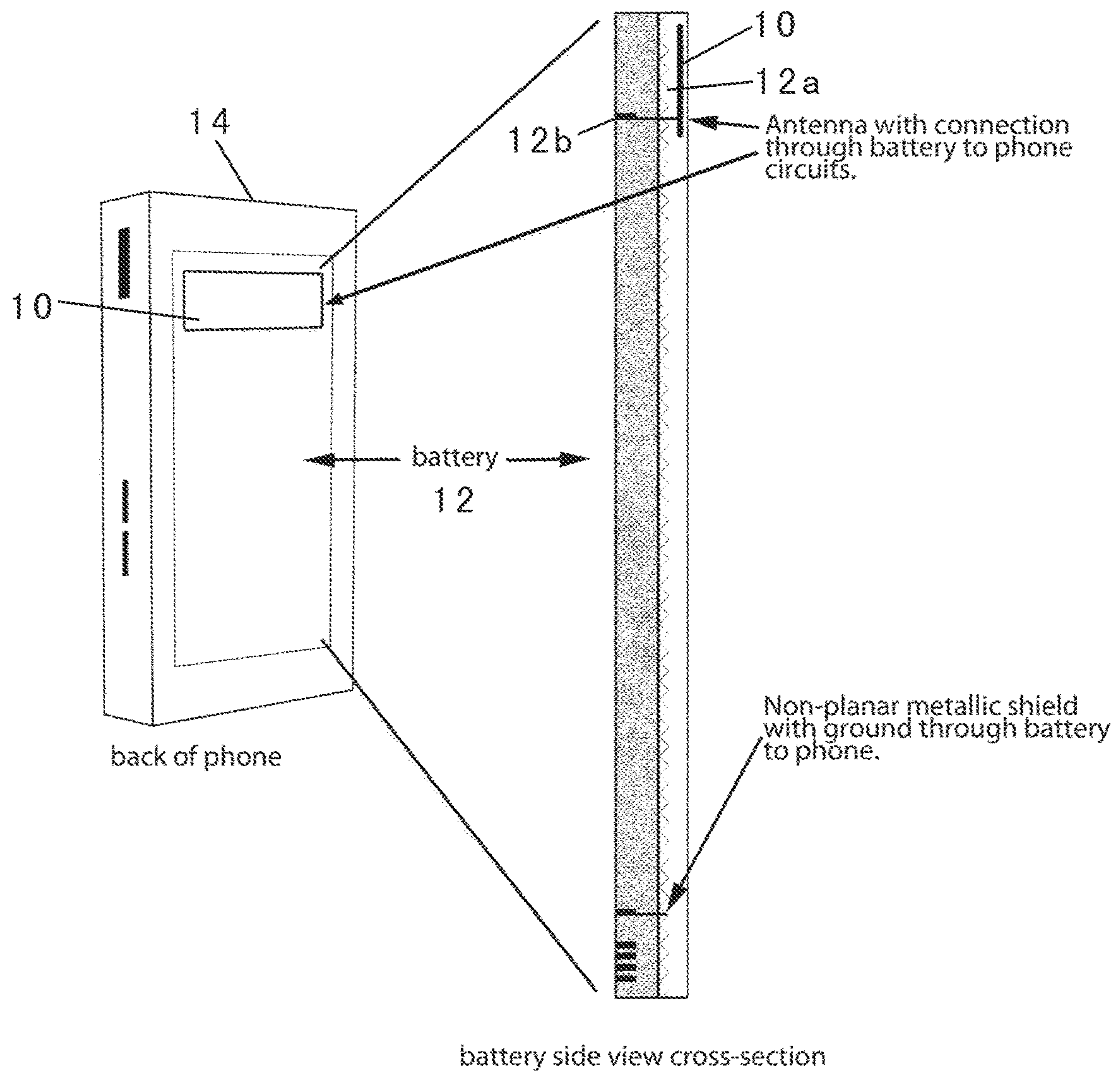


FIG. 1

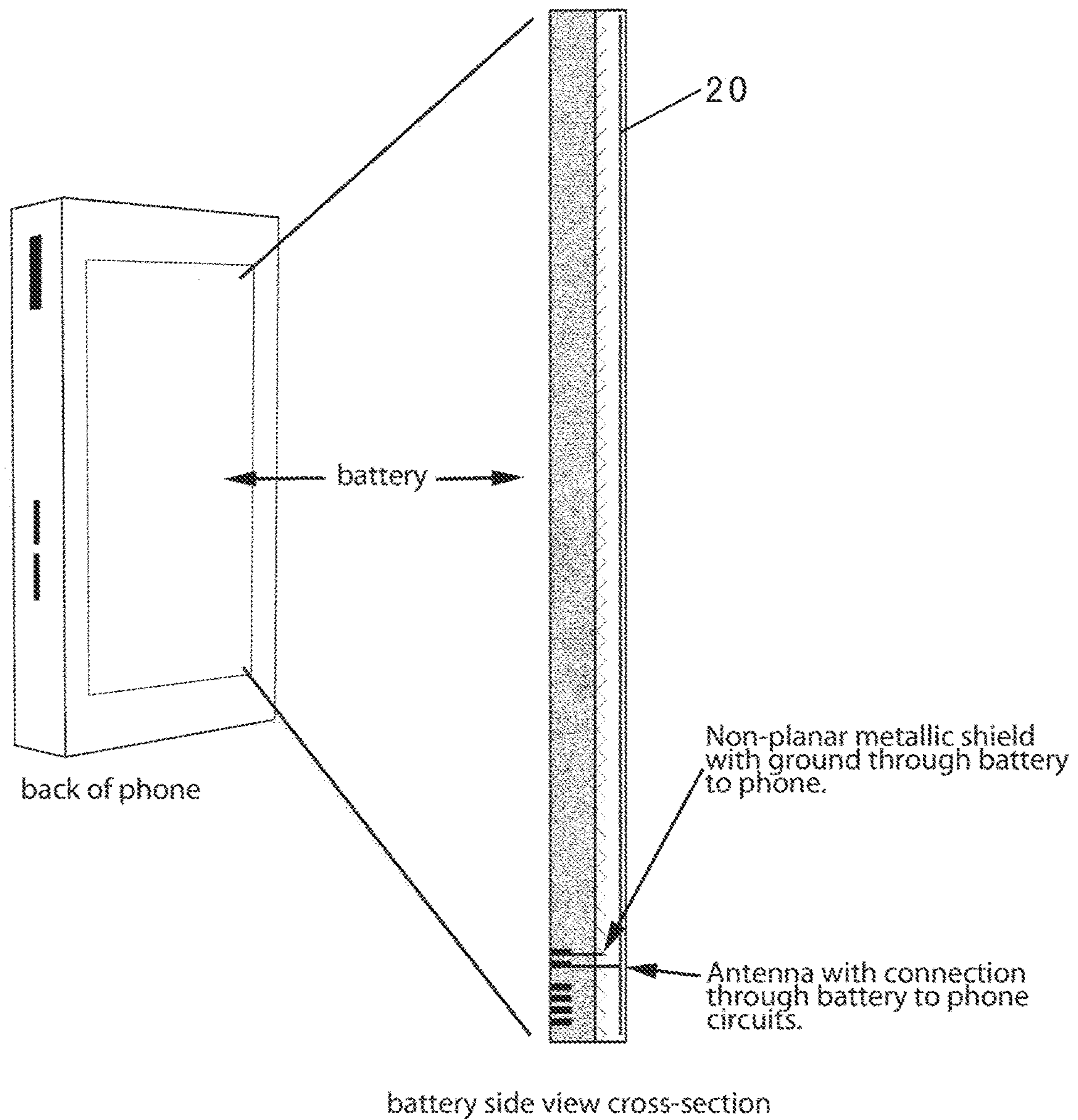


FIG. 2

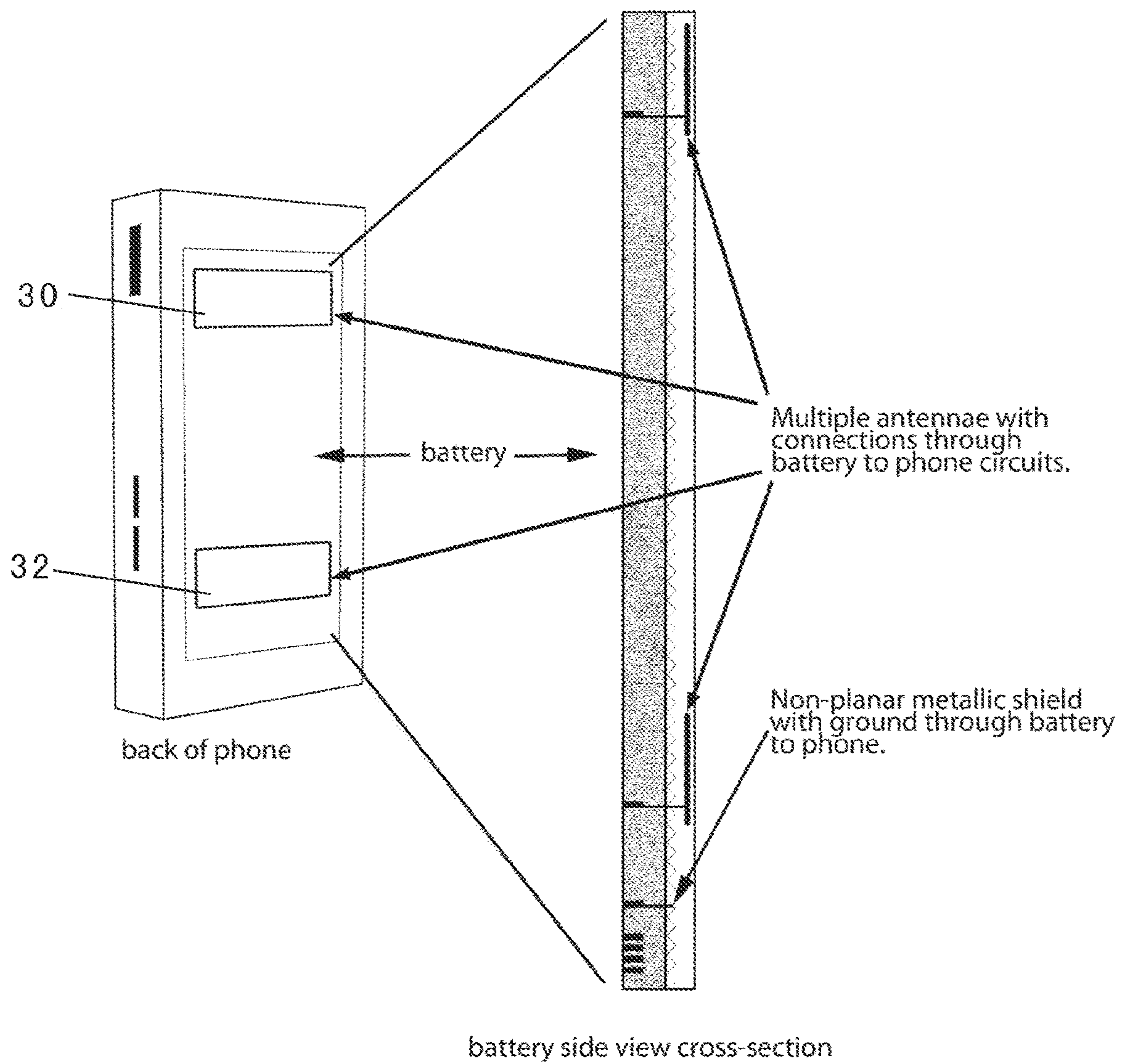


FIG. 3

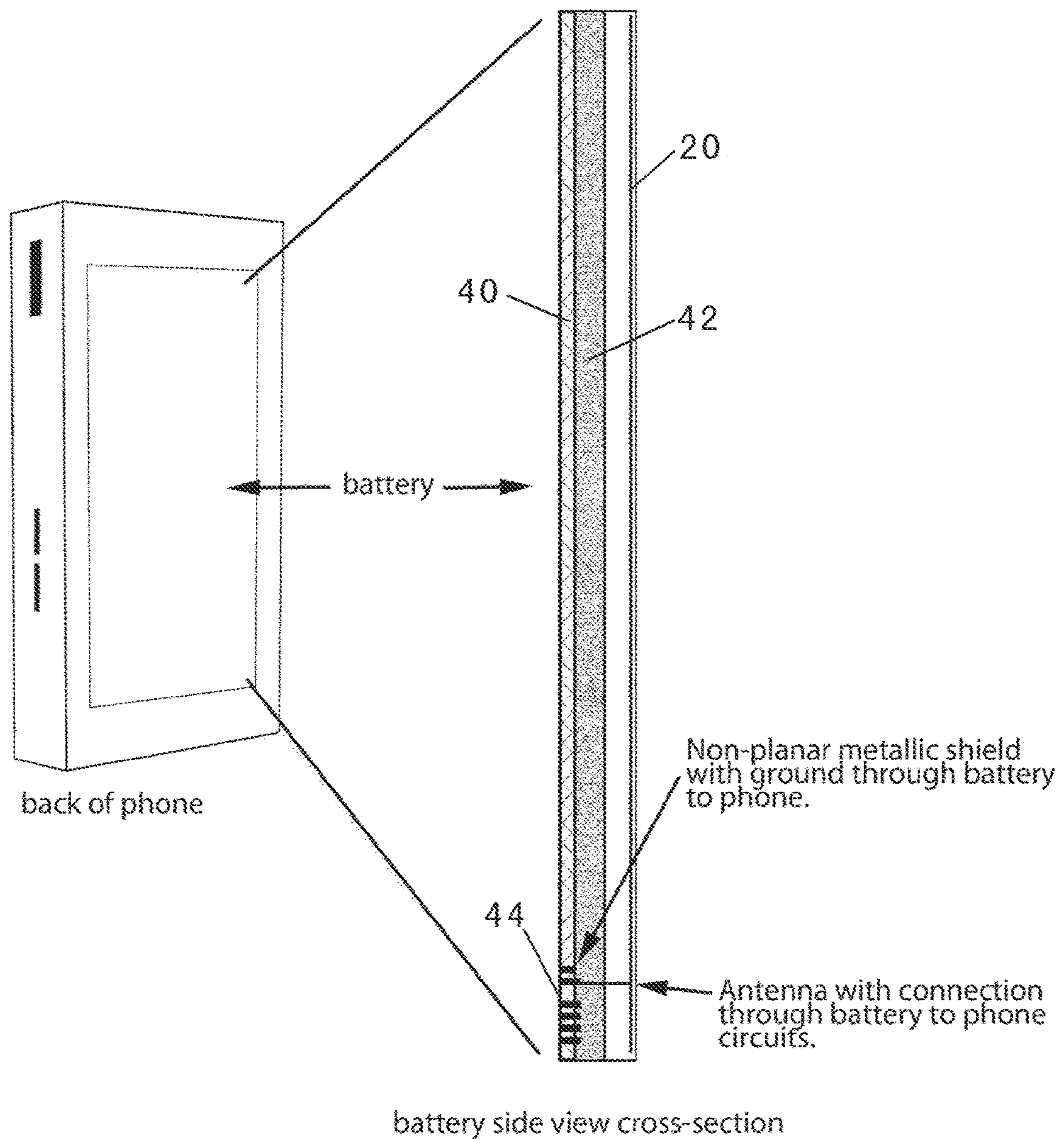


FIG. 4

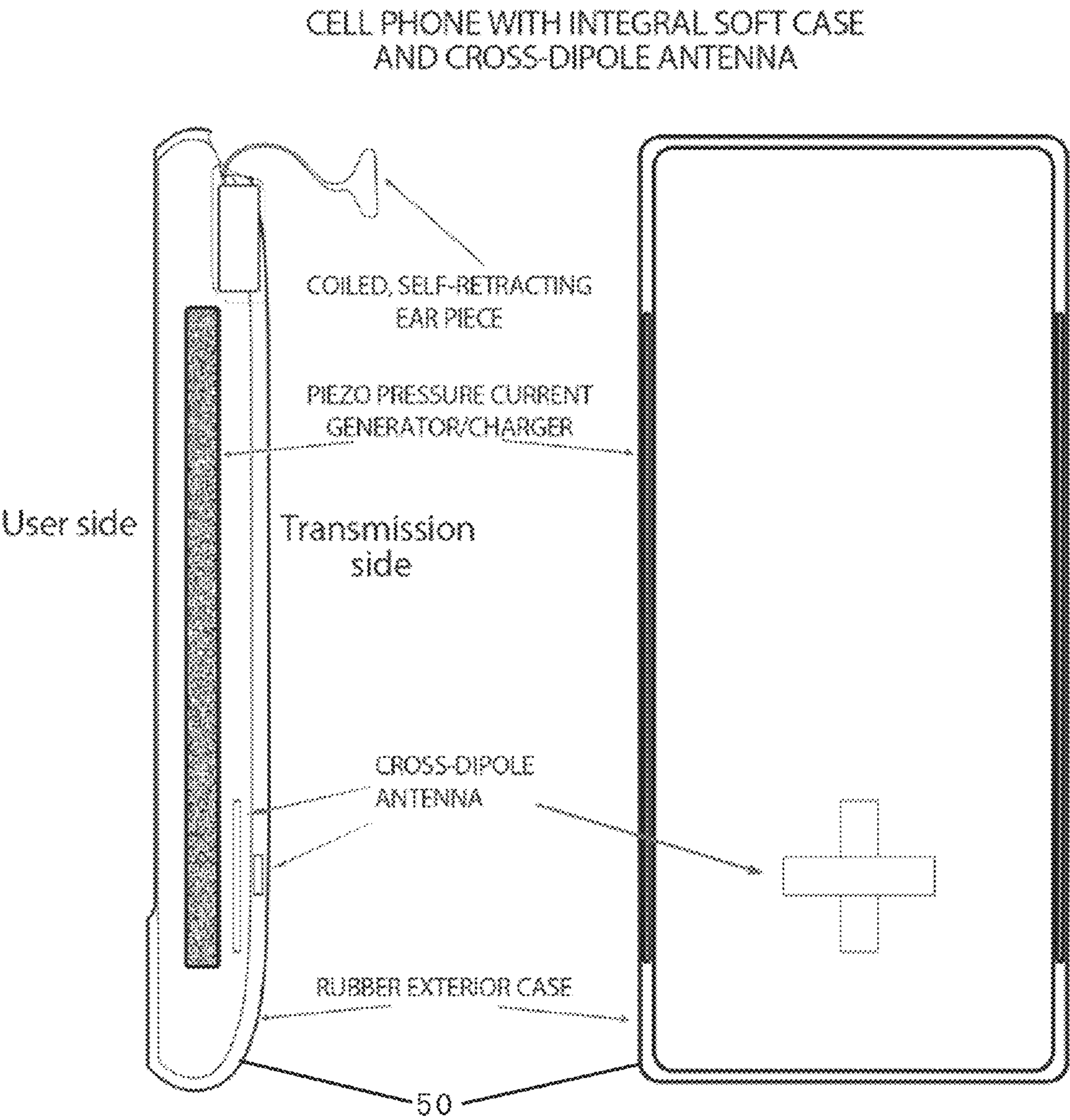


FIG. 5

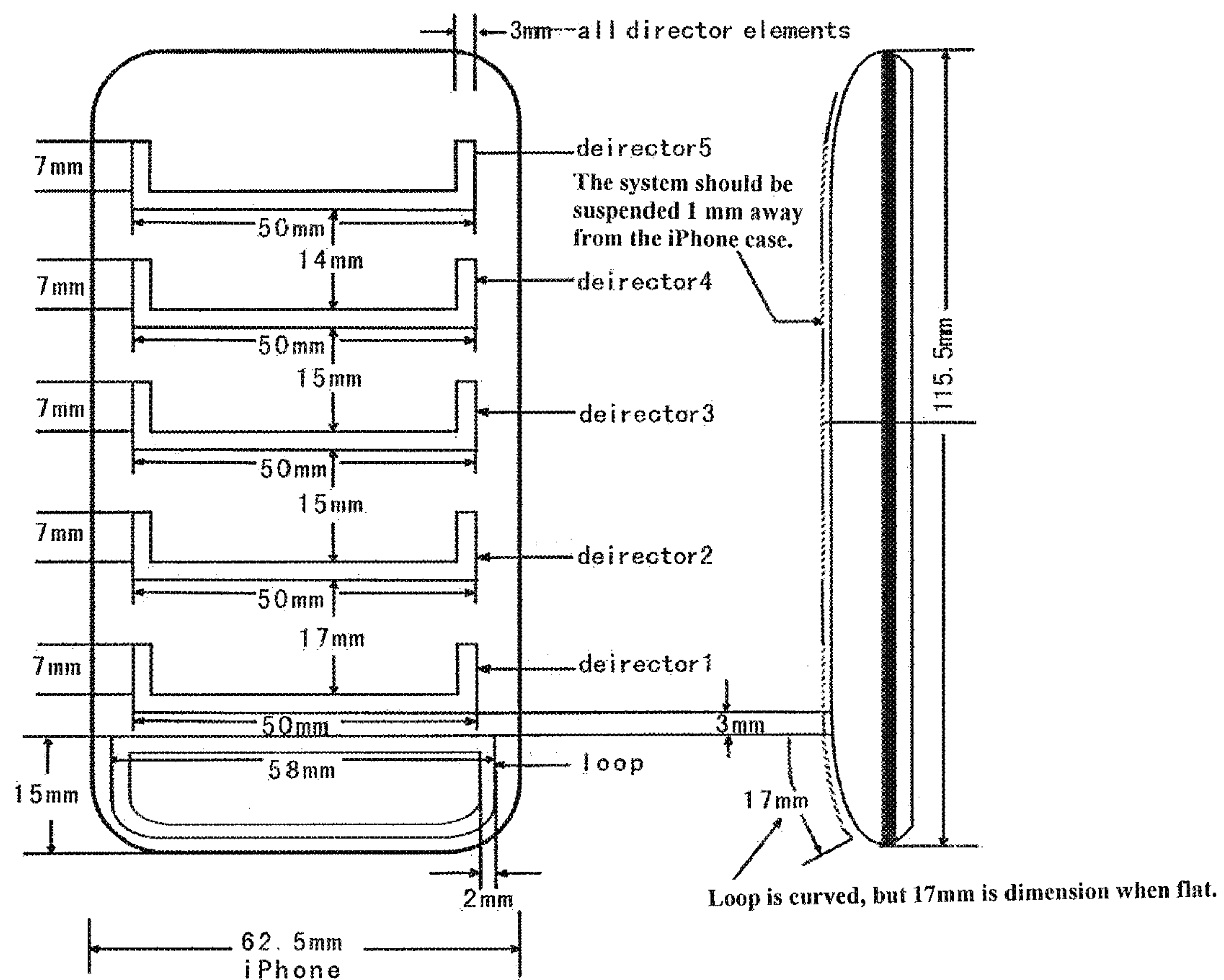


FIG. 6

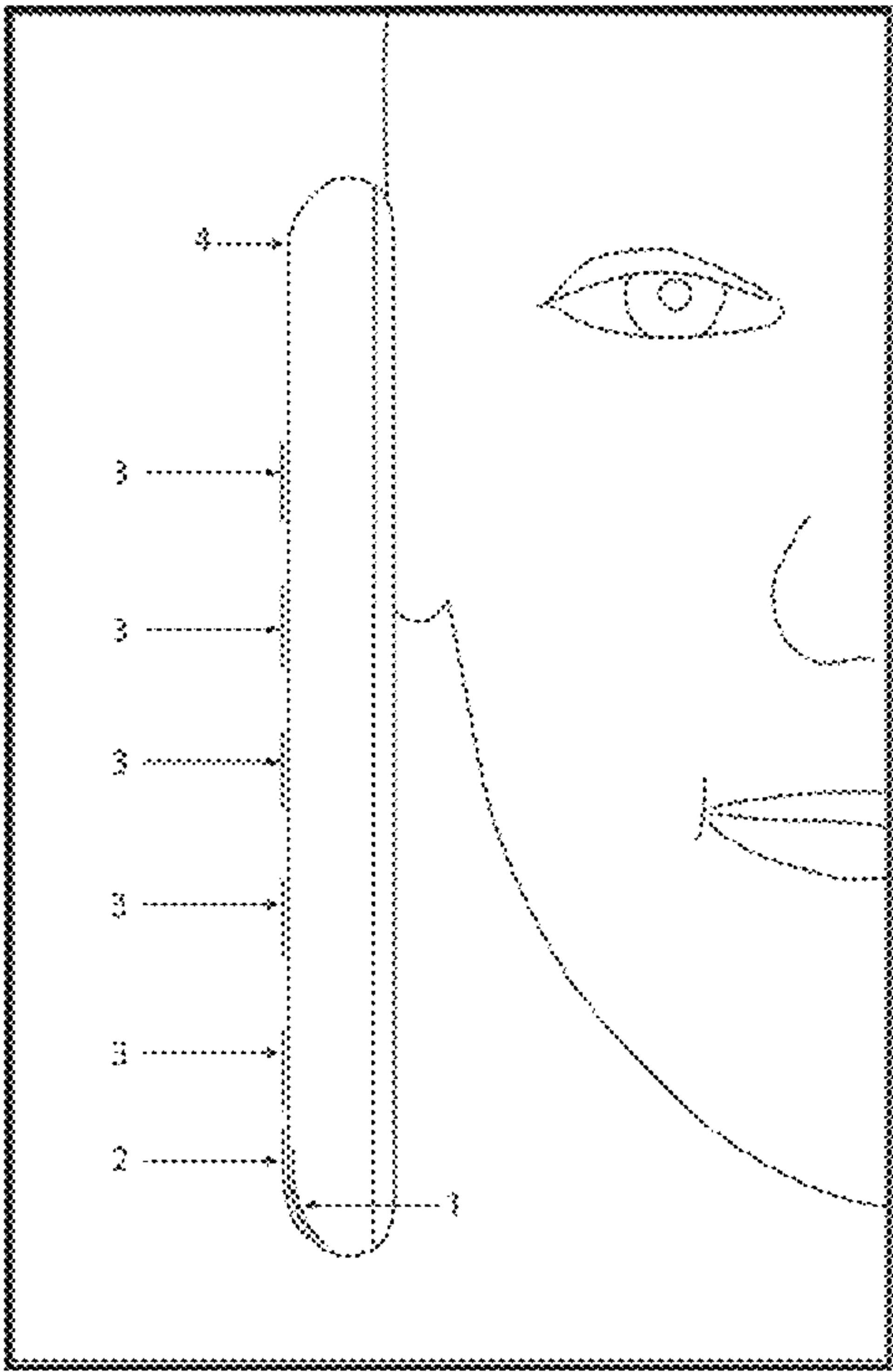


FIG. 7A

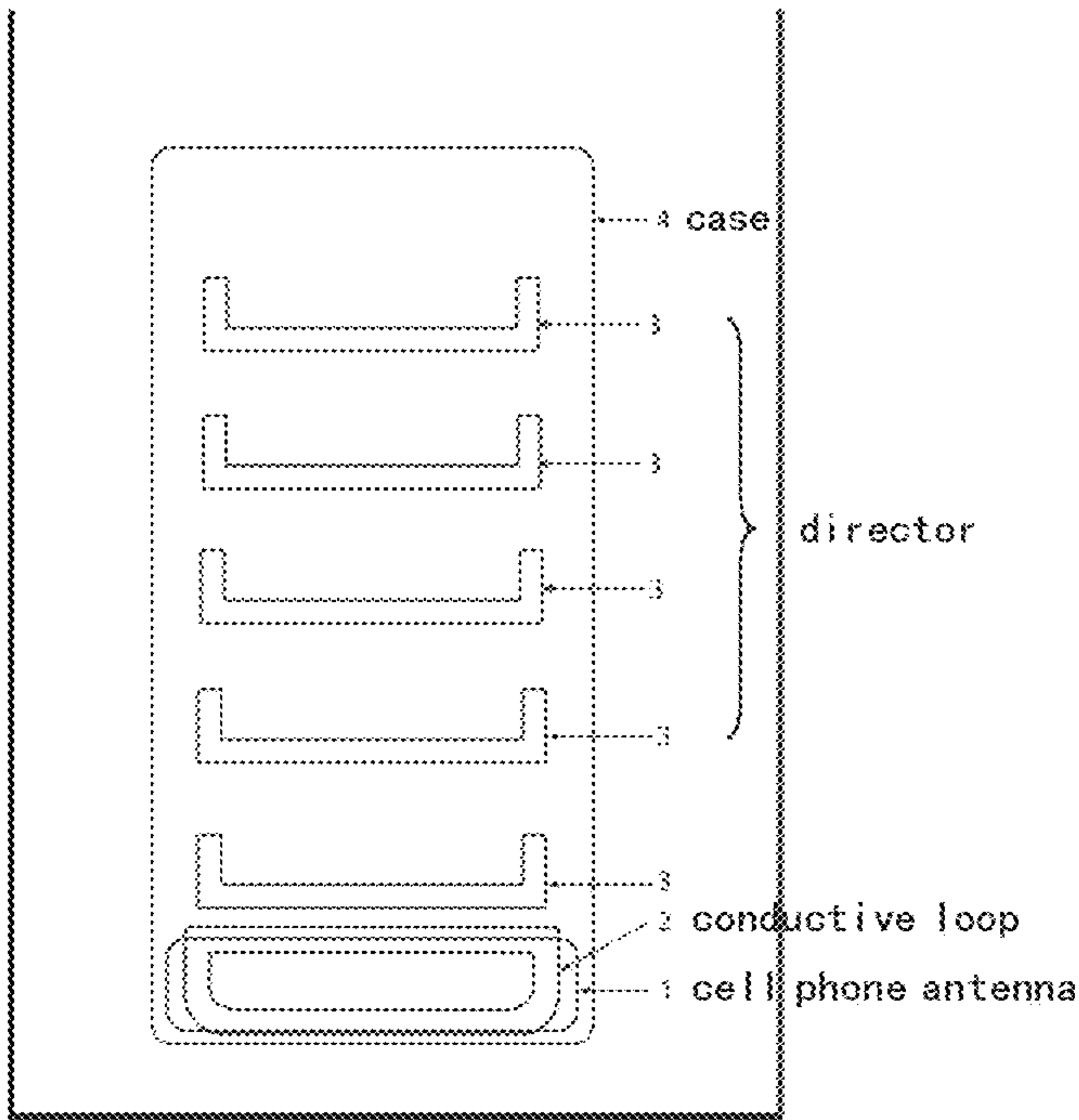


FIG. 7B

PONG CASE WITH RF SHIELD

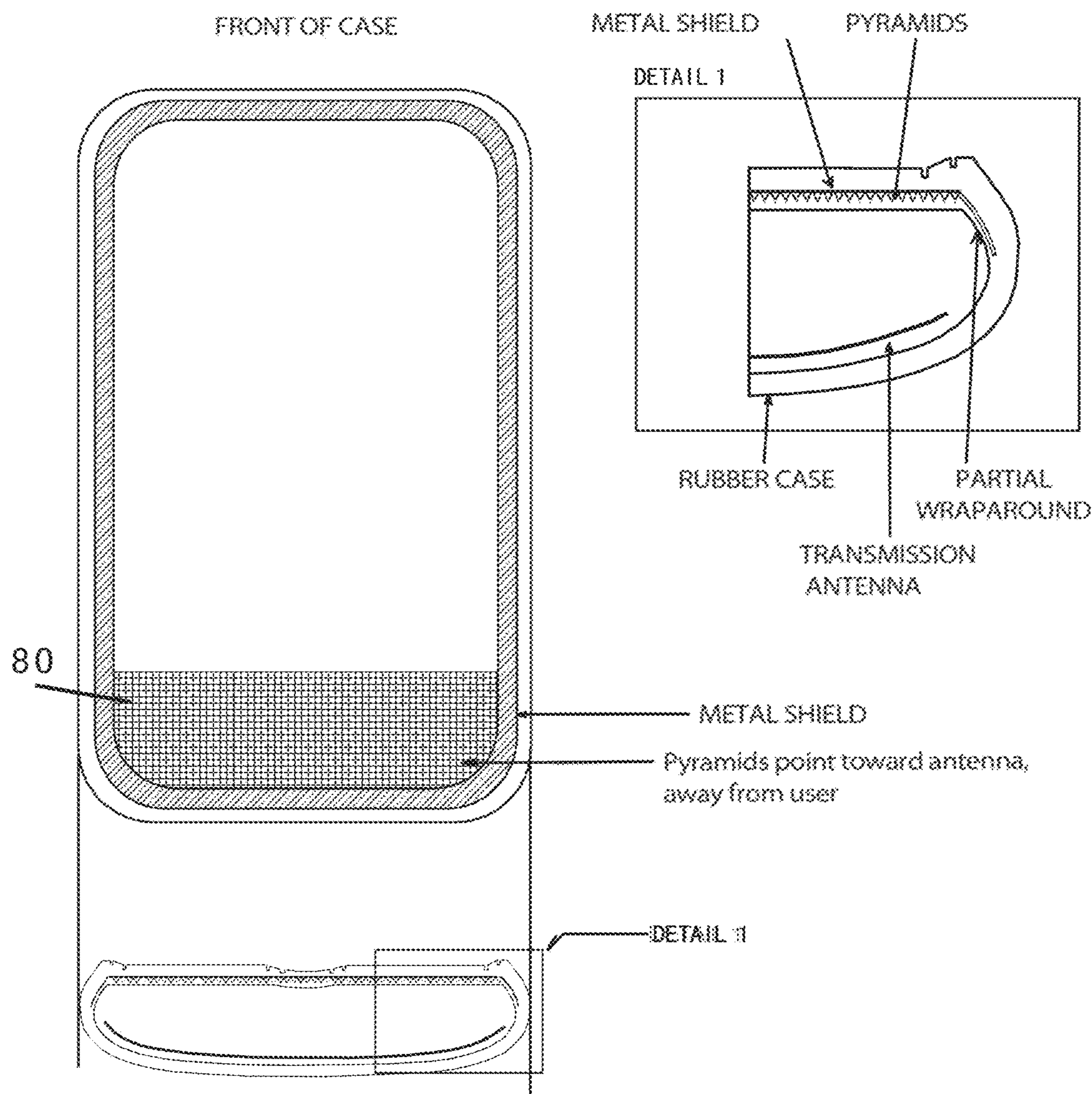


FIG. 8

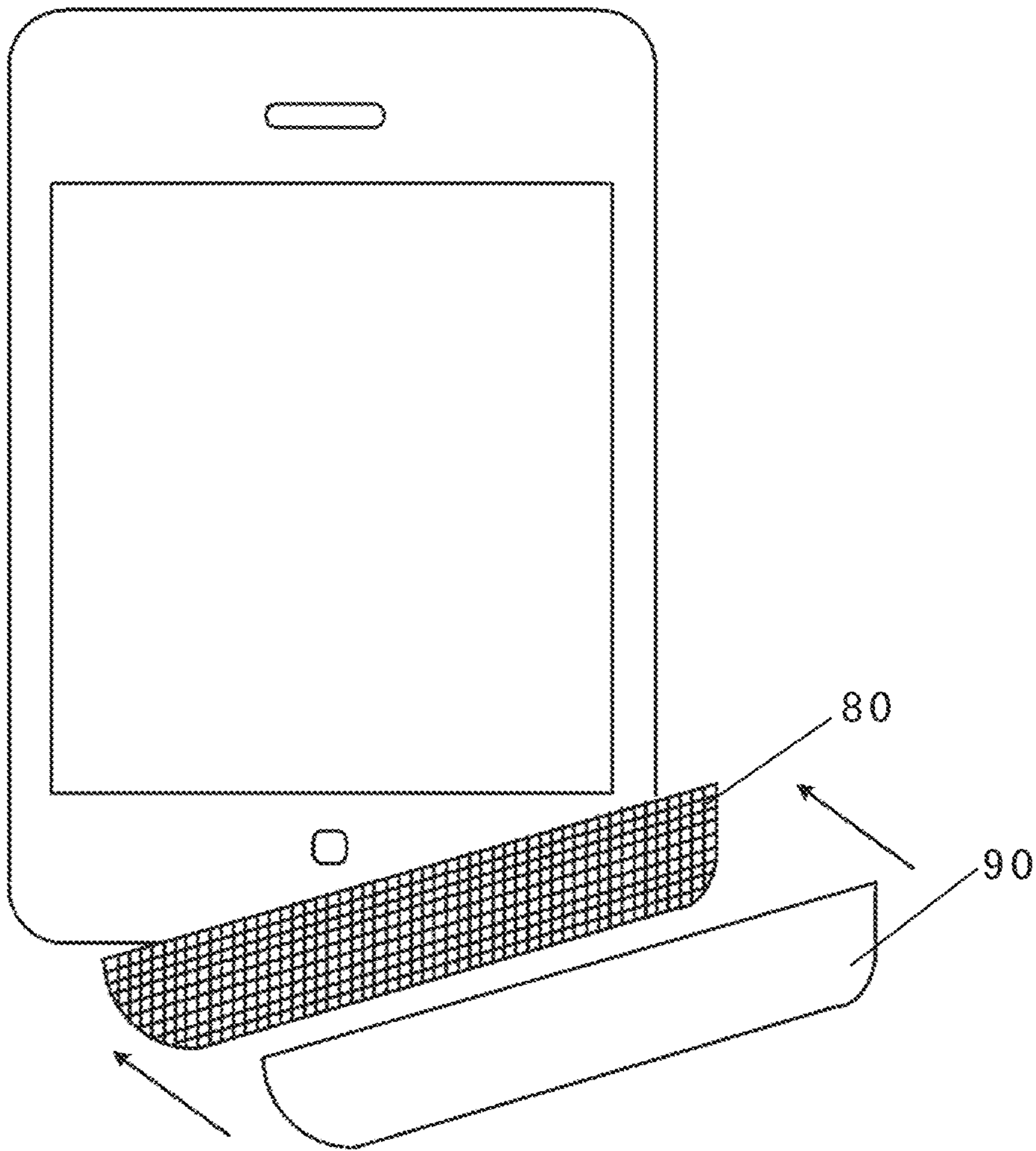


FIG. 9

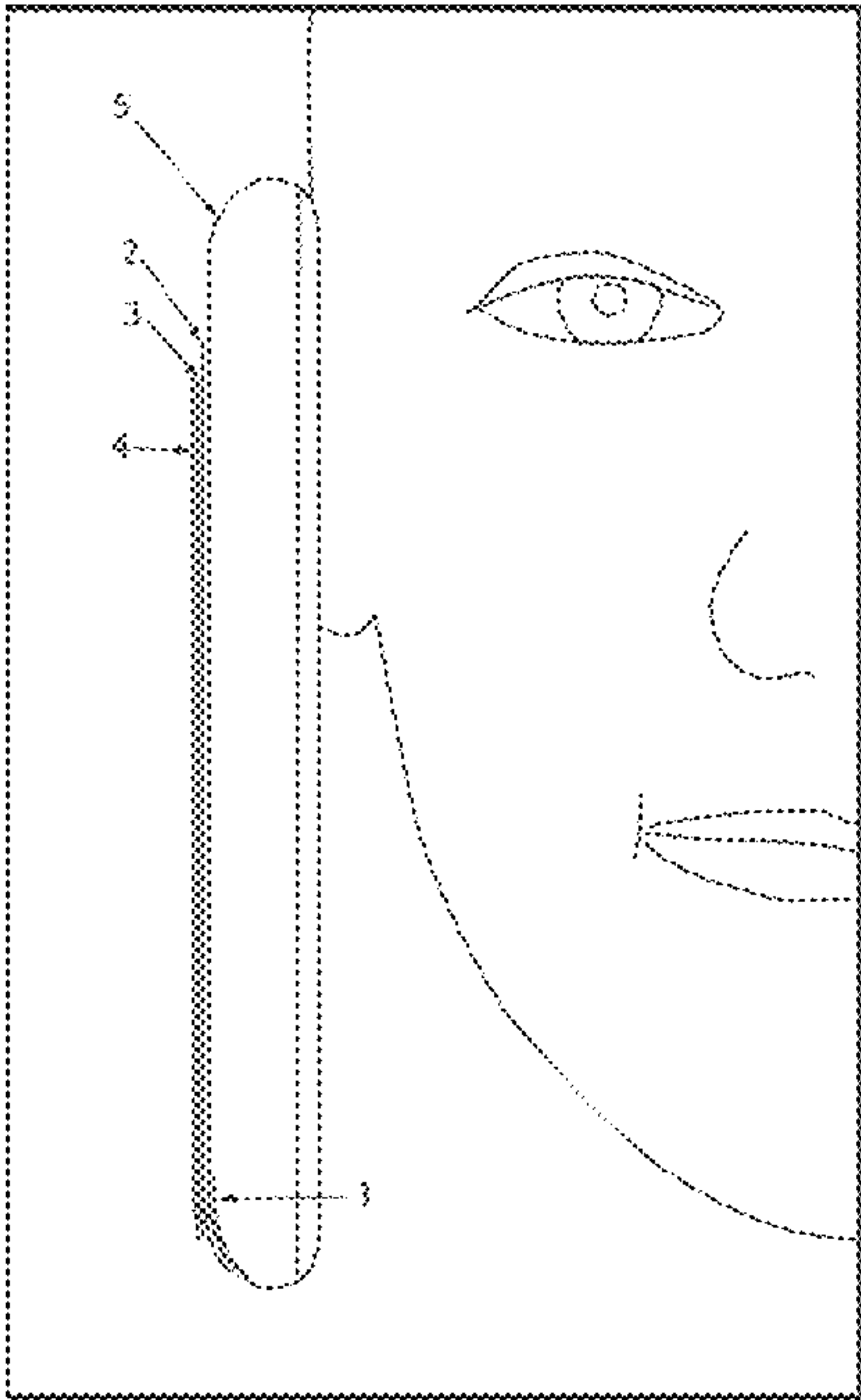


FIG. 10

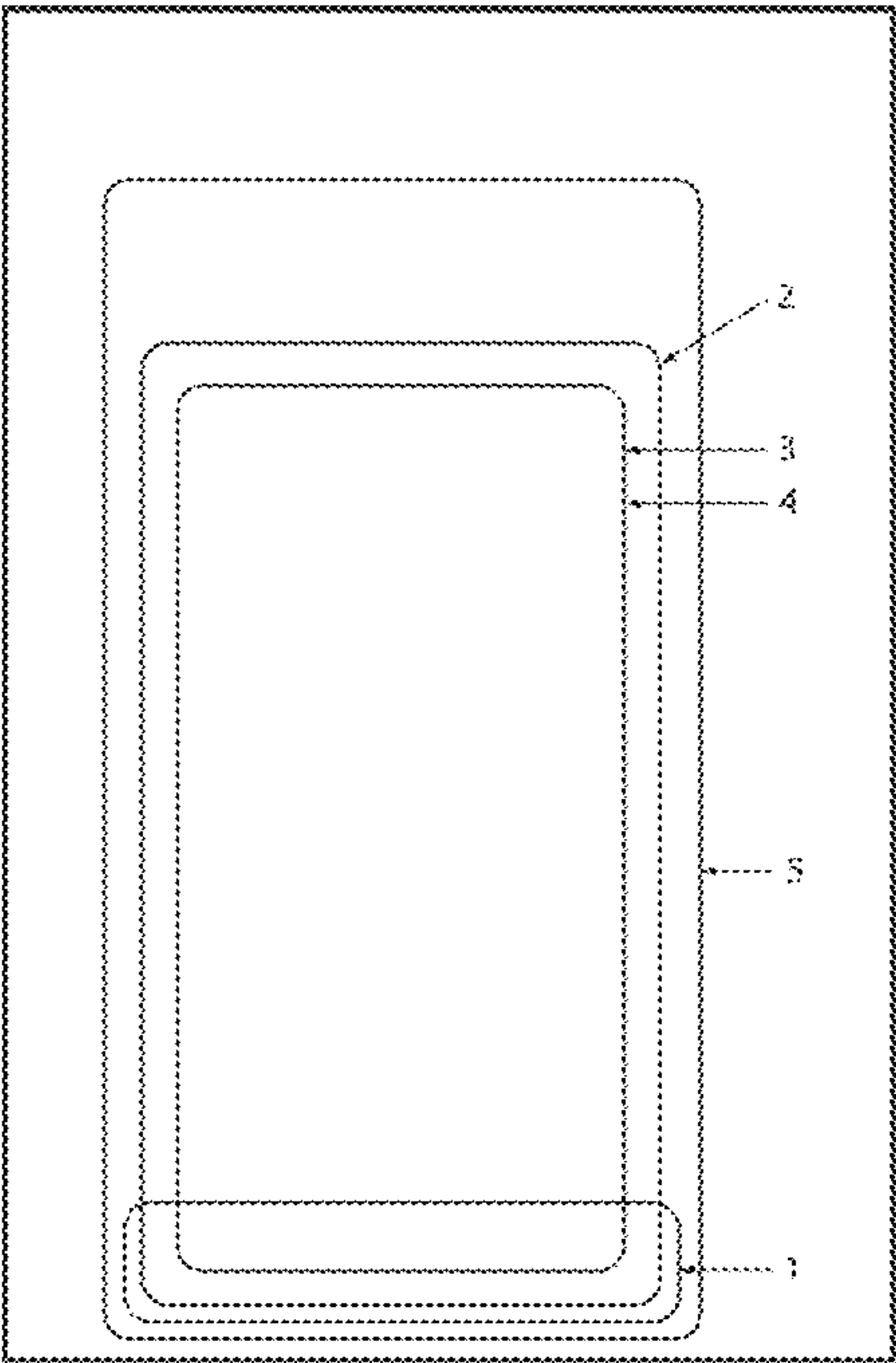


FIG. 11

iPHONE WITH PONG HYBRID ACTIVE
RF SHIELDING AND OPTIMIZATION

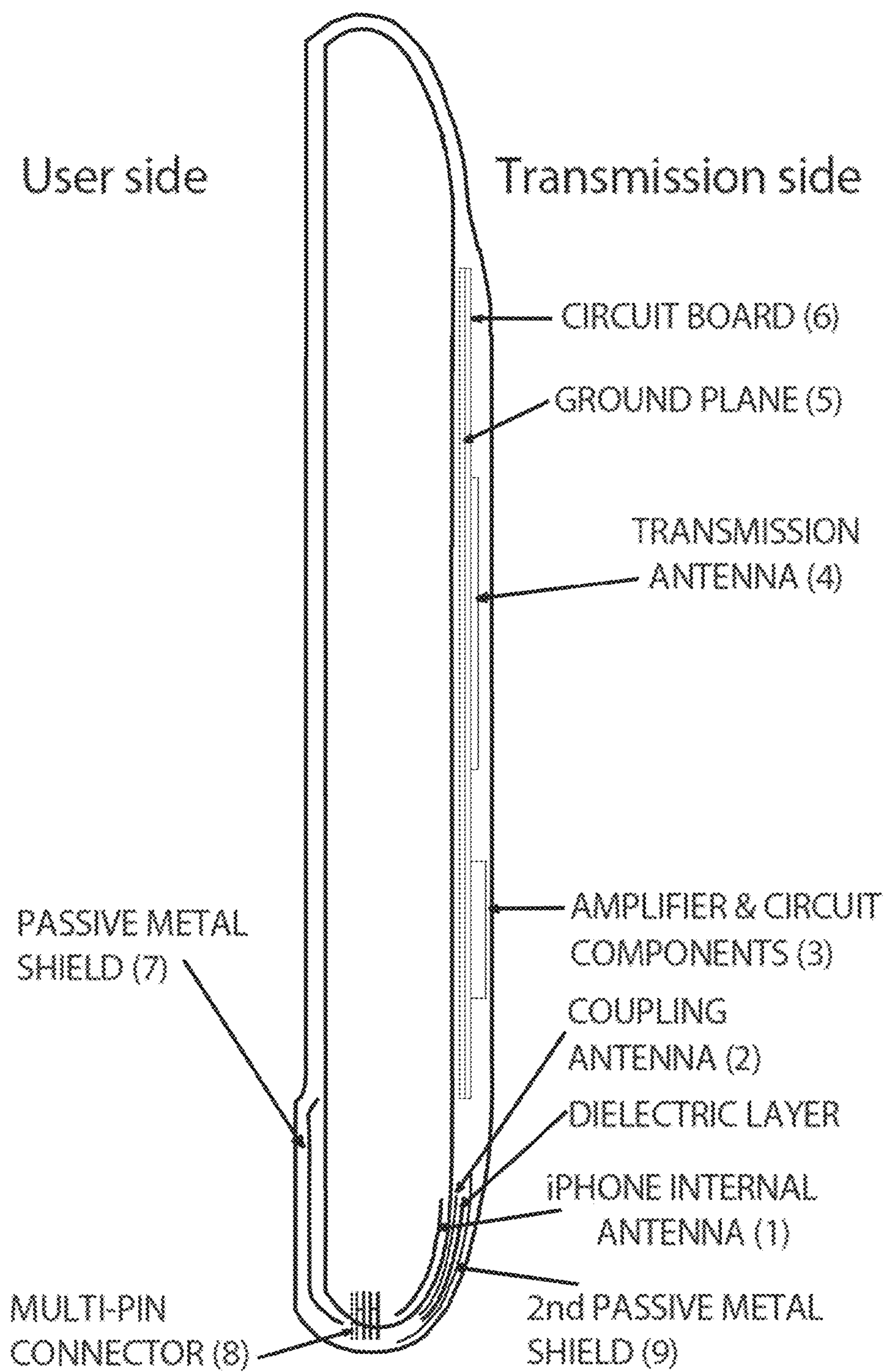


FIG. 12

Fig. 13 Example of Tri-band planar antenna to be used on the back surface away from the user.

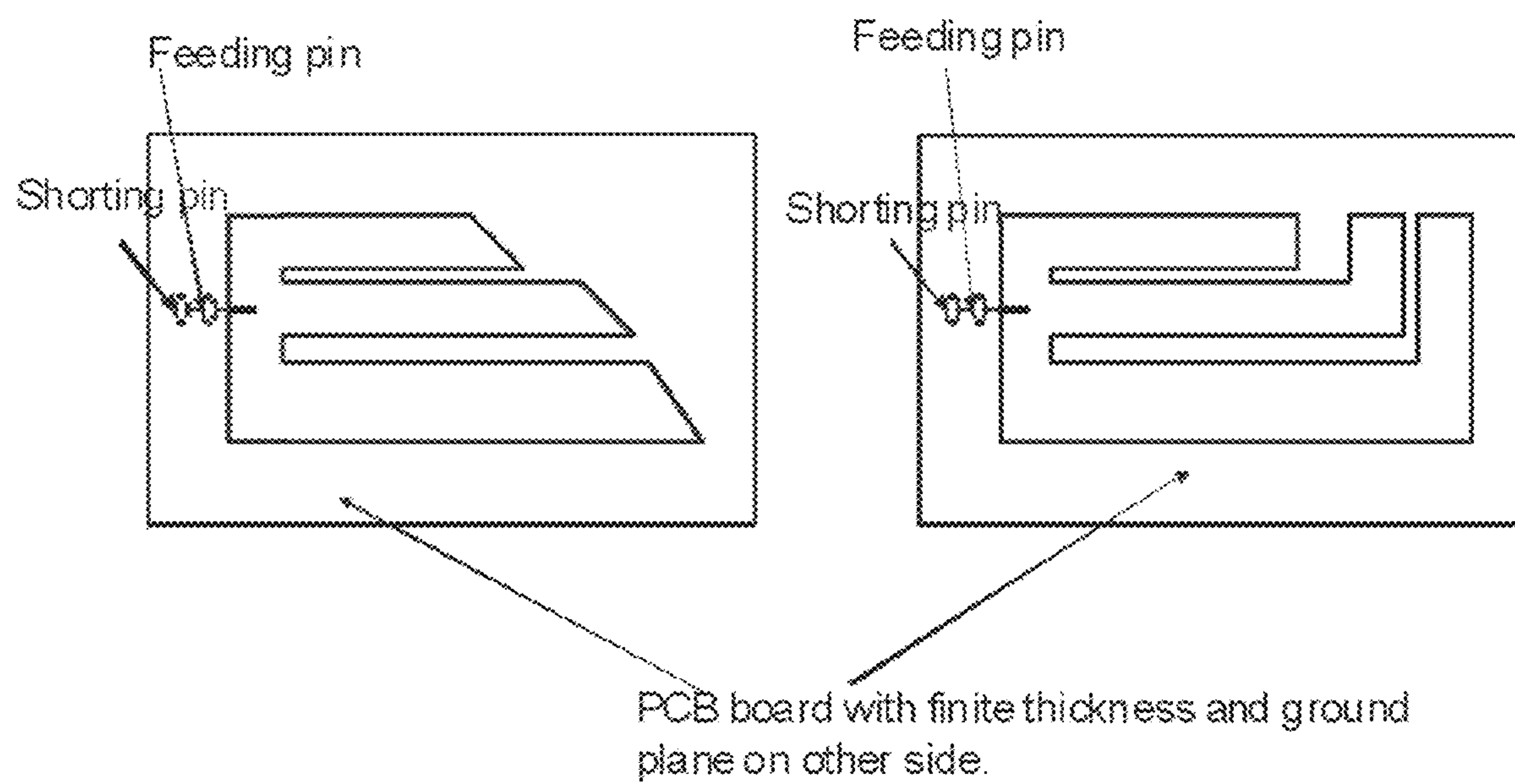


FIG. 13

Fig 14. Phase Control For Multiband Operation
1745 to 2100 MHz

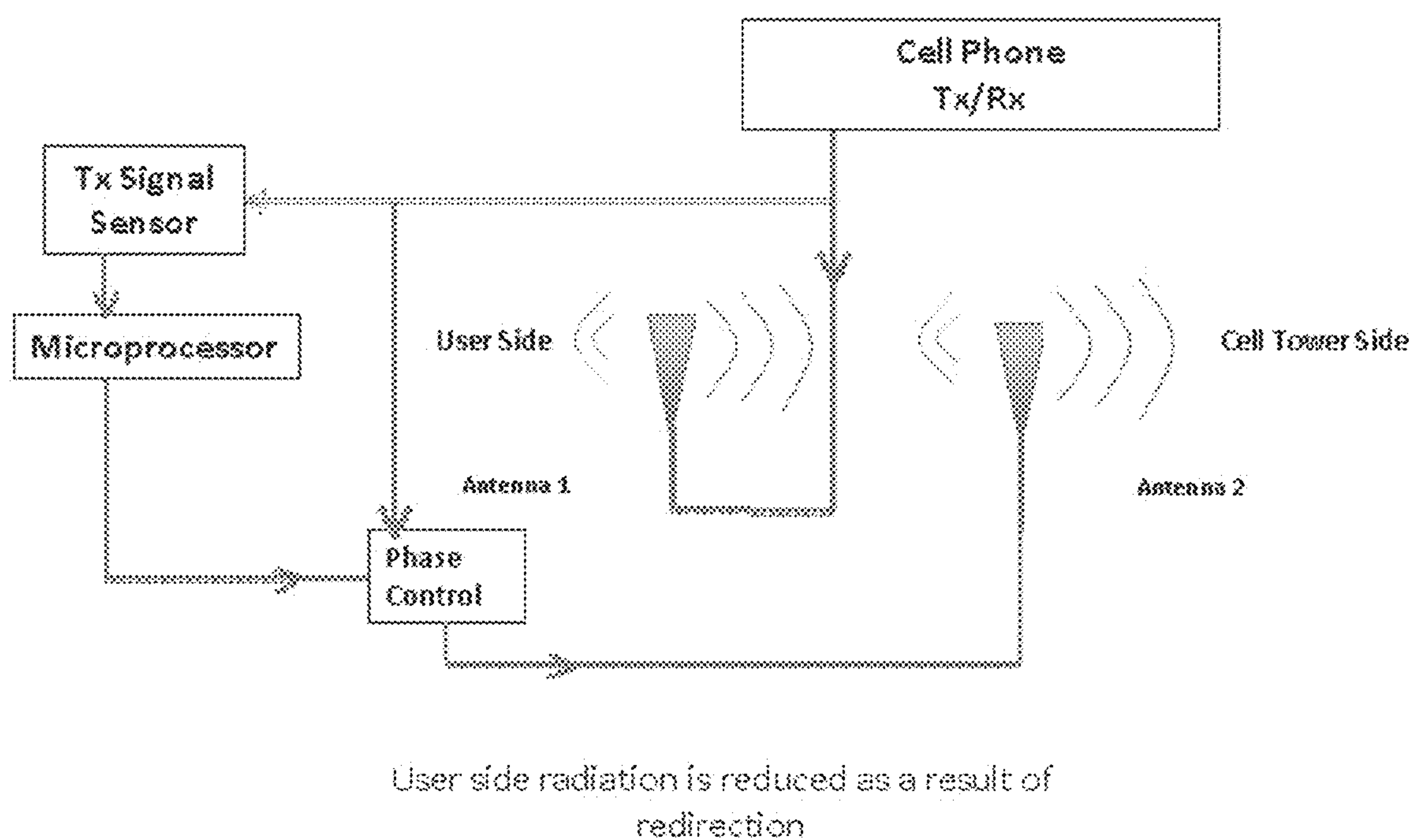


FIG. 14

RADIATION REDIRECTING ELEMENTS FOR PORTABLE COMMUNICATION DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS AND CLAIM FOR PRIORITY

This application is a continuation of U.S. patent application Ser. No. 13/894,039, entitled "RADIATION REDIRECTING ELEMENTS FOR PORTABLE COMMUNICATION DEVICE," filed May 14, 2013 (now U.S. Pat. No. 8,750,948), which is a continuation of U.S. patent application Ser. No. 13/491,747, entitled "RADIATION REDIRECTING EXTERNAL CASE FOR PORTABLE COMMUNICATION DEVICE AND ANTENNA EMBEDDED IN BATTERY OF PORTABLE COMMUNICATION DEVICE," filed on Jun. 8, 2012 (now U.S. Pat. No. 8,442,602), which is a continuation of U.S. patent application Ser. No. 12/614,132, entitled "RADIATION REDIRECTING EXTERNAL CASE FOR PORTABLE COMMUNICATION DEVICE AND ANTENNA EMBEDDED IN BATTERY OF PORTABLE COMMUNICATION DEVICE," filed on Nov. 6, 2009 (now U.S. Pat. No. 8,208,980), which claims priority to and the benefit of Provisional Application Ser. No. 61/112,141, entitled "Antenna Embedded In Battery of Mobile Phone and Other Similar Wireless Devices and Smart Case For Wireless Device," filed Nov. 6, 2008, and Provisional Application Ser. No. 61/158,551, entitled "External Case For Portable Communication Device To Redirect Radiation Away From User's Head," filed Mar. 9, 2009, all of which are incorporated herein by reference in their entirety.

BACKGROUND

1. Field of the Invention

This invention relates generally to portable communication devices such as cell phones, smart phones and similar handheld devices, and improvements thereto. In particular, this invention provides improvements in antennas and RF shielding of such devices, the embedding of an antenna into the removable battery of a portable communication device, or any large surface area inside a phone, facing a direction away from the user, to redirecting RF radiation away from the body of a user, and to several methods of exploiting technical advantages that result from embedding an antenna into the battery.

2. Background

Design requirements of cellular phones and smart phones are placing an ever increasing premium on the available space within these devices as their functions become more diverse, ranging from the original basic function as a wireless telephone to a music player, video player, handheld computer, wireless internet device for browsing the web, retrieving email and downloading or uploading files, a still camera, a video camera, a GPS device, a navigation system, etc. These functions bring with them greatly increased demands upon the antenna and generally requires more radiation power for transmission, which must serve up to five frequency bands while occupying less space than ever before available for the antenna.

In addition, RF radiation from mobile phones is becoming of greater concern as a health risk, and addressing this issue in the design of the antenna while the space within the phone is reduced poses a particularly difficult challenge, as the only effective methods of significantly reducing RF radiation in the direction of the user, while allowing full power RF signal away from the user, require some additional space for the antenna.

The FCC requires limiting the radiation from a portable communication device (such as a mobile or cellular telephone) that is directed towards a user's head (Specific Absorption Rate, or SAR). Each year the FCC tends to lower the permitted level further. One of the reasons is safety. At the same time, as wireless communications technology advances, the mobile phone device has taken on the function of a hand-held computer with more data-intensive functions, requiring high rates of data transfer between the cell phone and the base station tower. It would be beneficial to the improved function of cell phones to be able to increase the power output of the antenna, but FCC regulations will not allow increased SAR.

The Smart Phone (e.g. iPhone, BlackBerry, etc.), for example, has an internal antenna(s) located at both the lower and upper parts of the phone, bordering the display area. The space for an antenna is usually limited to 1 cm times the width and thickness of the phone. The antenna is situated close to the back surface of the phone, on the side opposite to the user.

SUMMARY

According to a first embodiment, the present invention dramatically increases the effective space for the antenna and provides highly effective shielding and RF radiation redirection away from the user, while actually increasing the available space within the phone casing. The invention incorporates the antenna into the battery such that the antenna lies on the side of the battery facing away from the user, where the battery is attached to the back of the phone facing away from the user. The battery's electrical connections are increased to include all the needed antenna leads into the phone's circuits. All batteries designed for a particular model of phone would feature the antenna built-in.

One advantage of this design is to afford far more space for the complex antennas of the future, aiding in their optimization. Separate antennas can be employed within the battery, utilizing the relatively larger area available on the battery to provide separation of antennas of different frequencies and functions, thereby reducing interference between the antennas. Another important advantage of this configuration is that it permits optimization of an RF shielding design for wireless phones. The thickness of the battery can serve to provide the needed space between the antenna and a tuned RF shielding element placed within the battery on the side nearest the user, with the lithium ion core or other functional storage medium of the battery lying between the shielding and the antenna. The resulting spacing between the RF shielding and the antenna is optimally one-quarter of the wavelength of the transmission signal. This goal can be aided by the use of a layer of dielectric material between the RF shielding and the antenna, but is still extremely difficult to achieve in the small space allowed inside the phone case. By designing the battery such that the thickness of the battery's storage medium results in the correct spacing for the tuning of the RF shielding, and by grounding the shielding through a connector from the battery to the phone's ground circuit, and by designing the RF shielding itself to optimally redirect the RF radiation away from the user while leaving undiminished the desired signal directed away from the user, a unique benefit of significant reduction in RF absorption by the user's body can be achieved.

An alternate way of redirection is to use two antennas phased appropriately to radiate waves in a direction away from the user. This can be achieved in two ways:

1. Place two antennas one on each side of the battery. Each antenna is connected to the output power. The phase between

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these antennas is controlled digitally to give the optimum direction outward. Micro-processor with very low power requirement (microwatt) is available for this digital control. The power for such control can be derived from capturing the radiation power from the phone.

2. This configuration is ideal for multiple-band applications. For each frequency used the phase is programmed to give the optimum propagation characteristics. This will make it unnecessary to have a material of high dielectric constant.

The same principle can be used where one antenna is located in the cell phone case and another antenna inside the phone or on/in the battery. In general, two or more antennas are preferred to direct the radiation from a wireless phone.

According to a second aspect of the invention, radiation from a portable communication device is directed away from the user such that there is minimum effect on the performance of the device. The end result is a low SAR and an unchanged TRP (Total Radiation Power). This is accomplished by coupling radiation from the antenna inside a wireless phone to an external case. The external case is provided with a shield comprising a metallic surface that is corrugated. Such a shield may also be installed inside the wireless device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an antenna embedded into a battery and the antenna connections from the battery casing to the phone circuits, with the antenna designed as a compact unit located at the upper end of the battery.

FIG. 2 shows an antenna embedded into a battery and the antenna connections from the battery casing to the phone circuits, with the antenna designed as a thin flat unit located on the planar surface in the back of the battery.

FIG. 3 shows separate antennas of different frequency and purpose located apart from one another in separate areas of the battery.

FIG. 4 shows an RF radiation shield embedded into the battery, such that the shielding is on the side of the battery nearest the user while the antenna is on the side of the battery farthest from the user in the same flat planar configuration as shown in FIG. 2. Also shown in FIG. 2 is the ground connection for the shielding through the battery to the phone's ground circuit.

FIG. 5 shows an exploded view of the battery with the antenna, the electrical storage medium, the RF shielding, and the dielectric layers identified, as well as the electrical connections for the battery power, the antenna and the RF shielding ground.

FIGS. 6, 7A and 7B show various views of a protective external wireless phone case provided with a passive coupling antenna incorporated into the back of the case in accordance with a first embodiment.

FIG. 8 shows a beam antenna combined with a shield having a metallic surface that is corrugated.

FIG. 9 shows layer of highly conductive corrugated metal shield of a specific design is, optionally, combined with a layer of absorptive material of a specific frequency range.

FIGS. 10 and 11 show various views of a protective external wireless phone case provided with a passive coupling antenna incorporated into the back of the case in accordance with a second embodiment.

FIG. 12 shows RF redirection material being integrated into the internal design of a wireless device.

FIG. 13 is a diagram illustrating a multi-band antenna located inside the wireless device, the phase of which can be controlled by a microprocessor to correspond to use of different communication frequency bands.

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FIG. 14 is a diagram illustrating the use of phase control of antenna propagation to direct electromagnetic radiation in a direction away from the user of the wireless device.

DETAILED DESCRIPTION

Antenna Embedded into Battery or Wireless Devices

According to first aspect of the invention as shown in FIG. 1, an antenna 10 for a wireless device 14 is embedded into the battery 12, such that the space inside the wireless device formerly occupied by the antenna is available for other components, and the antenna is connected to the wireless device's antenna circuit by electrical contact surfaces 12a on the battery casing that contact corresponding surfaces 12b on the phone case, in the same manner as the power connections are made from the battery to the phone's power circuit. The antenna may be of compact design and fitted into one end or side of the battery casing, as shown in FIG. 1. Optionally, the antenna may be made thin and flat and may be placed on the broad flat plane parallel to the battery's energy storage core as shown in FIG. 2 as antenna 20.

As shown in FIG. 3, separate antennas 30 and 32 of different frequencies may be provided on the battery located apart from one another in various areas within the battery. For example, one antenna 30 may be designed for quadband performance, and another separate GPS antenna 32 may be added in another area of the battery case with its own circuit and connections through to the wireless device.

In another embodiment of the invention as shown on FIG. 4, an RF shield 40 is embedded into the battery such that the energy storage core material 42 of the battery lies between the shielding 40 and the antenna 20. The antenna is grounded to the wireless device's ground circuit by contacts 44 in the same manner as the antenna connection described above. The battery is designed such that the thickness of the energy storage core causes the spacing between the RF shielding and the antenna to be one-quarter of the wavelength of the transmission signal. This tuning of the relationship of the RF shielding to the antenna can be enhanced by the embedding of a layer of dielectric material between the RF shield and the antenna.

The main feature of this design for a battery case is that the antenna for the wireless device is embedded within the battery rather than inside the wireless device. Various configurations of the antenna within the battery case are possible and obvious to any person of ordinary skill in the art.

In the embodiment of this invention wherein an RF shield is embedded into the battery case, only the side of the battery facing the user contains the shielding while the side away from the user is made from non-conducting or low-conductive materials allowing the EM wave to propagate outward towards the cell phone tower without suffering any attenuation.

Incorporation of this RF shield inside the battery will aid in satisfying the FCC requirement limiting the radiation that is directed towards the user's head (Specific Absorption Rate, or SAR). Over time the FCC may tend to lower the permitted SAR level even further. At the same time, as wireless communications technology advances, the cell phone has taken on the function of a hand-held computer with more data-intensive functions, requiring high rates of data transfer to and from the cell phone tower. While it is beneficial to the improved function of cell phones to increase the power output of the antenna, FCC regulations will not allow such an increase in the SAR if the radiation is isotropic. The device of the present invention wherein the radiation is redirected away from the user and towards the base station fulfills both the

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requirements of the FCC and the technical communication requirements of ever increasing data rates in mobile entertainment and communication devices.

FIG. 5 further illustrates the concept of a “smart” case 50 for a wireless communication device. A smart case is one which is connected to a communication device such as a cell phone through a connector such as the lower multiple pin connectors on the body of the cell phone. It expands the capability of any phone by providing more usable space for a second antenna, a manual charging system, an earpiece (which does not carry RF into the ear), or additional memory in addition to its functioning as a carrying case. Examples of these multiple functions are shown in FIG. 5, although it should be emphasized that there is a great deal of flexibility in the arrangement of these units mentioned above, and the arrangement of FIG. 5 thus is not limiting of the scope of this inventive concept.

The advantage of this smart case is to always improve a given cell phone whose function is to transmit and receive signals, while the case can always upgrade the function of a cell phone. One of the most important functions of such a case is to provide a second antenna which if phased properly will provide the redirection feature without the use of a high-dielectric material. In order to make a multiple band antenna directional it is important to use a phased array so that radiation always will be emitted from one side of the phone.

According to a second aspect of the invention, radiation is coupled from the antenna inside a wireless phone to an external case where the distribution of radiation can be better managed. Several arrangements of directing RF radiation away from the user’s head by the appropriate placement of metallic loops and other parasitic elements are presented. This can take the form of arrays of dipole antennas, conducting loops and conducting plates with insulators or dielectrics. The general concept is to couple the radiation from the internal antenna on the side facing the user to the opposite side of the device, where there is sufficient space inside an external case to direct such radiation outward and away from the user. The coupling must be designed to direct the radiation without causing a drop in the output of the external amplifier. From an engineering point of view the impedance seen by the output amplifier should not change. From a physicist’s point of view there should be minimum radiation power reflected back on the radiating antenna of the cell phone.

In one preferred embodiment of this aspect of the invention, “coupling antennas” are used to direct radiation from the internal antenna of a wireless phone to a large surface of a carrying case such that there is minimum radiation towards the user and maximum radiation away from the user. It is important to note that this coupling method does not require an actual physical connection between the case and the interior of the phone. However the position of the coupling antenna with respect to the internal antenna is critical. Through a series of coupling loops, Yagi antennas or patch antennas, the radiation is further directed away from the user’s head which is absorptive and towards his surroundings for communication to cell towers. The materials used for coupling and re-directional elements are generally made out of materials of high electric conductivities, although dielectric materials are also used to achieve optimal physical spacings.

In the preferred embodiment of the invention as shown in FIGS. 6, 7A and 7B, a protective external wireless phone case 4 is provided with a passive coupling antenna (which may be a Yagi, loop or patch antenna) incorporated into the back of the case, on the side away from the user. This antenna works as a directional antenna consisting of an array of a dipole and

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additional closely coupled parasitic elements (e.g. a reflector 2 and one or more directors 2) and directs the radiation from the internal antenna 1 up, out and away from the phone. In this preferred embodiment the beam antenna may also be substituted by a loop or patch antenna.

In another embodiment of the invention as shown in FIG. 8, the beam antenna may be combined with a shield 80 comprising a metallic surface that is corrugated, giving rise to many image dipoles, thereby providing a wide pattern of radiation. The particular shape and size of the corrugations is critical, the objective being to disperse the reflected radiation as widely as possible. The corrugations are preferably of comparable size or smaller than the spacing of the shield from the antenna.

In an alternate embodiment of the invention as shown in FIG. 9, the layer of highly conductive corrugated metal shield 80 of a specific design is combined with a layer of absorptive material 90 of a specific frequency range, inserted between the internal antenna and the user, such that with the phone inserted into an external case the materials would be placed as indicated.

The redirection of RF radiation away from the user’s head may also be achieved by the use of a properly located passive beam antenna as shown in FIGS. 10 and 11, with or without the corrugated shield of highly conductive metallic material, and with or without a layer of absorptive material.

A main feature of this invention, whether as a passive directional beam antenna alone, or in combination with a passive re-directional shield incorporated in an external case for a wireless phone, or such combination incorporated internally in a wireless phone device, is that the invention directs/redirects radiation away from the user and out of the phone towards a cell tower, reducing SAR without adversely affecting TRP. It does this with a combination of a directional antenna and re-directive shield integrated within a case of non-conducting or low-conductive materials (variously of silicon, plastic, cloth, etc.) that allow EM waves to propagate outward towards the cell phone tower without suffering any attenuation.

The same RF redirection would be the result of the material(s), in these various embodiments, being integrated into the internal design of the wireless device, as shown in FIG. 12.

The invention may also be embodied in an active case, where the power that drives the external antenna embedded in the external case comes from the cell phone’s internal battery via the phone’s built in power port. The power can also come from solar cells embedded into the external case. It can also come from mechanical motion of a piezoelectric or other similar mechanical to electrical generator.

The invention includes a directional beam-antenna (Yagi, loop or patch) integrated into the external case on the back side of the phone away from the user, floated within the external case with a general tolerance for placement optimally within ± 0.020 " (± 0.5 mm). This antenna works as a directional antenna consisting of an array of a dipole and additional closely coupled parasitic elements (a reflector and one or more directors). These elements are made of specific planar metal material (copper or gold, for example). The dipole in the array is placed over the phone’s internal antenna, effectively coupled by proximity and within a specific tolerance of placement, but optimally at 5%, and driven by said internal antenna. Another element, 10% longer, operates as a reflector. Other shorter parasitic elements are added in front of the dipole as directors. Elements arranged optimally at approximately a one-quarter-wavelength mutual spacing and being progressively slightly shorter than a half wavelength, optimally positioned within a 10% tolerance, direct signals of

increasingly higher frequencies onto the active dipole. The beam-like antenna has directionality, directing radiation away from the reflector through the driven element and out via the directors in the top of the wireless device, producing a chimney effect.

The directional antenna may also be a loop or patch antenna where said antenna is on the back of the phone, away from the user's head, placed optimally 3 mm below the plane containing the iPhone antenna. The loop is offset along the X-axis so that the edge is between the ground sheet and the antenna element. If a patch antenna is used, the patch director is square in shape, and each side is optimal in length. These are free space lengths, corrected for dielectric constant (velocity factor). The patch director functions like the loop director.

The metallic surface is preferably non-planar so that the electromagnetic waves radiated by antennas are reflected into a widely scattered area. The non-planar surface causes reflections of radiation from a single dipole into a much wider area than a planar surface and a single dipole. The metallic surface may be corrugated, curved, or may be folded.

This highly conductive metal imbedded in the external case to reflect the radiation should be corrugated in a specific way (e.g. rows, chevrons, pyramids), to a specific height and width of corrugation. It should be of a specific thickness; optimally, greater than the skin depth of the EM wave at the cell phone frequency. The metal shield may also be flat. The placement on the face of the wireless phone with respect to the internal antenna(s) is specific.

Another condition for efficiency is that the separation between the metal layer and the enclosed antenna should be occupied by a broadband resonant absorptive material having a specific frequency range that is loaded for predetermined loss tangents and that functions on an impedance matching principle. The material is placed over specific areas to limit radiation to the user. However the case is able to redirect radiation effectively, if not optimally, even when the conditions above are not met.

Although the foregoing features described above deal with antennae located in the lower part of the phone, it will be apparent that the same concept can be applied to antennas located in the upper part or other areas of the phone.

A simplification of applying the radiation redirection and shielding can be by use of adhesive patches applied directly onto the area over the antenna; a first patch over the antenna on the side opposite the user (i.e. toward the cell tower) and a second patch between the antenna and the user. In this embodiment the beam antenna, the highly conducting corrugated shield and, optionally the frequency-targeted resonant absorptive layer, can be sandwiched between two non-conducting layers, one of which contains an adhesive surface to be applied directly onto the phone. The user will receive the protection whether the case is applied over it or not. It is apparent that this simplification can be applied to any case and to any phone. Appropriate covering might be necessary to secure this patch in place for more permanent application. Incorporation of the Shield During Manufacturing

Instead of a case described above, a passive coupling and redirection unit can be installed inside a wireless device, provided the appropriate spacing is used between this coupling unit and the original cell phone antenna. This is made possible by the fact that both the coupling loop and the Yagi directors can all be lined up in a plane with a thickness of 1-2 mm.

Instead of using a case featuring the above described shield can be built into the wireless device; either the beam antenna, alone, or in combination with the corrugated metallic shield,

or in combination with the absorptive frequency targeted, can be incorporated directly within the phone's structure. The plastic/metal housing of the phone facing the user will have a liner with a conducting metal layer and, optionally, an absorptive layer, separating the beam antenna, the metal layer and the internal antenna. This has the advantage that the phone is complete with the shield right from the factory.

Another effective method has emerged that is a hybrid approach, combining the passive redirection with the active driver amplifier and battery in the external case. This method uses the cell phone antenna and power amplifier system as a wireless feed to the amplifier/antenna system inside the external case. The final transmission power is to be radiated from an antenna inside the external case. Therefore, the cell phone system serves only as the low power driver, which couples to the final power amplifier (PA) for final transmission to cell stations. Since the antenna in the case can be a patch antenna with a ground plane occupying a space greater than the radiating antenna, we should expect the radiation pattern to be that of a patch antenna. The radiation pattern is hemispherical and will satisfy our goals of achieving a high directional TRP and at the same time low SAR.

As the base station tower receives a strong signal from the external case antenna, it signals the cell phone to lower its power. The cell phone antenna now radiates only a small amount of energy since it acts only as a low-power drive to the external case system, which is performing all the real transmission work. As the cell phone lowers its power, its radiation towards the user will be correspondingly lower even if a shield is not present. When a shield is included on the user side the radiation towards the user will be further reduced. In fact, the effect of the passive shield of suppressing the TRP of the cell phone's antenna is now an advantage to us, as it will allow the Pong antenna to be the dominant antenna. The efficiency of the cell phone's antenna is no longer critical, as it only needs to communicate with the external case's coupling antenna located a few millimeters away.

This design is, in principle, simple. It substitutes the antenna and PA in the external case for the original cell phone antenna. The external case antenna is directional while the cell phone antenna is isotropic or omni-directional. There is more space in the external case for antenna and RF amplifiers with additional power supplies. Once the cell tower receives the necessary power P_t from the cell phone configuration with the radiating case, it will automatically command the cell phone to emit at a lower level $P_i = P_t/A$, where A is the gain of the RF amplifier in the case.

Referring to FIG. 12, the cell phone's internal antenna (1) couples with the coupling antenna (2), and the signal is processed by the amplifier circuit (3), driving the external case's transmission antenna (4). Passive metal shields (7) and (9) block RF from the cell phone's antenna, both reducing radiation toward the user and suppressing the antenna's radiated power. The external case circuit draws its power from the cell phone battery through the multi-pin connector (8). This external case embodiment can have its own battery supply, charged through a connector at the bottom of the case while the cell phone's battery is also being charged. However, the system can also function by drawing the power from the cell phone. Since the power draw of the cell phone transmitter will be lowered dramatically and the load shifted to the external case antenna, the net draw of power from the battery should be nearly the same as the standalone cell phone. The amplifier in the external case can be either the same or more powerful than the cell phone. These two batteries are intended to lengthen the period of usage of a wireless phone.

FIG. 13 shows an additional embodiment using multiband antennae, one on each side of the battery or a suitable large surface such a printed circuit board (PCB) surface inside the device. The relative phase between these two antennae is adjustable through a microprocessor such that the radiation is directed away from the user. The separation between these two antennae can be any distance because of the control of relative phase between these two antennae. The phase between these two antennae can be controlled digitally according to the frequency band being used by the wireless device. The information used for the control of the phase can be obtained from a sensor or detector that determines the frequency band being used. The phase difference between the two antennae is adjusted to optimize minimum power being directed towards the user and directing maximum power away from the user. This digital control allows a multi-band operation with low SAR and acceptable or enhanced TRP. In FIG. 13, the antennae are tri-band antennae and are located on the surface of an internal PCB opposite to a ground plane.

FIG. 14 is a diagram illustrating an embodiment of the use of phase control to control the phase difference between two antennae, Antenna 1 and Antenna 2, so as to redirect radiation in a direction away from the user of the wireless device (cell phone). A transmission signal sensor Tx Signal Sensor detects the signal being sent to the antennae by the transceiver of the cell phone. This Signal Sensor determines the frequency band being used by the cell phone for communication with the cell tower (base station), and sends a corresponding signal to the Microprocessor. The Microprocessor in turn sends a control signal to a phase controller (Phase Control), which controls the phases of the Antenna 1 and Antenna 2 to create a predetermined phase difference between the antennae, appropriate for the particular communication frequency band being used, and directing the radiation from the antennae away from the user.

What is claimed is:

1. An apparatus, comprising:
a wireless communication device having an antenna, a first coupling element and a second coupling element,
the second coupling element and at least a portion of the first coupling element are disposed within a plane, the antenna is disposed outside of the plane,
the first coupling element redirecting radiation from the antenna to the second coupling element when the wireless communication device is operational, the second coupling element redirecting radiation away from a user of the wireless communication device when the wireless communication device is operational.
2. The apparatus of claim 1, wherein the wireless communication device has a body, the antenna, the first coupling element and the second coupling element being disposed within an interior of the body.
3. The apparatus of claim 1, wherein the first coupling element redirects radiation and the second coupling element redirects radiation when the wireless device is operational such that a specific absorption rate (SAR) of the wireless communication device is reduced without substantially adversely affecting a total radiation power (TRP) of the wireless communication device.
4. The apparatus of claim 1, wherein a distance between the first coupling element and the second antenna is less than a distance between the second coupling element and the antenna.
5. The apparatus of claim 1, wherein at least a portion of the first coupling element is disposed over at least a portion of the antenna, the second coupling element is not disposed over the antenna.

6. The apparatus of claim 1, wherein the first coupling element and the second coupling element each is at least one of (1) a loop, (2) a Yagi element, (3) a patch, or (4) a strip.

7. An apparatus, comprising:

- a wireless communication device having an antenna, a first coupling element and a second coupling element,
- a distance between the first coupling element and the second coupling element is less than a distance between the second coupling element and the antenna,
- the first coupling element redirecting radiation from the antenna to the second coupling element when the wireless communication device is operational such that a specific absorption rate (SAR) of the wireless communication device is reduced without substantially adversely affecting a total radiation power (TRP) of the wireless communication device.

8. The apparatus of claim 7, wherein the wireless communication device has a body, the antenna, the first coupling element and the second coupling element being disposed within an interior of the body.

9. The apparatus of claim 7, wherein the antenna is disposed between a user of the wireless communication device and the first coupling element when the wireless communication device is operational and disposed by a head of the user.

10. The apparatus of claim 7, wherein at least a portion of the first coupling element is disposed over at least a portion of the antenna, the second coupling element is not disposed over the antenna.

11. The apparatus of claim 7, wherein the wireless communication device has an amplifier circuit operationally coupled to the first coupling element and the second coupling element, the amplifier circuit configured to amplify the radiation from the first coupling element before the radiation is received by the second coupling element.

12. An apparatus, comprising:

- a wireless communication device having an antenna, a first coupling element and a second coupling element,
- the first coupling element redirecting radiation from the antenna to the second coupling element when the wireless communication device is operational, the second coupling element redirecting radiation away from a user of the wireless communication device when the wireless communication device is operational,
- the first coupling element and the second coupling element being disposed between the antenna and the user when the wireless communication device is positioned for use relative to the user.

13. The apparatus of claim 12, wherein:

- the wireless communication device includes a body,
- the antenna, the first coupling element and the second coupling element being disposed within an interior of the body.

14. The apparatus of claim 12, wherein at least a portion of the first coupling element is disposed over at least a portion of the antenna, the second coupling element is not disposed over the antenna.

15. The apparatus of claim 12, wherein the first coupling element and the second coupling element each is at least one of (1) a loop, (2) a Yagi element, (3) a patch, or (4) a strip.

16. The apparatus of claim 12, wherein:

- the wireless communication device has an amplifier circuit,
- the amplifier circuit amplifying the radiation before the radiation is received by the second coupling element when the wireless communication device is operational.

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17. The apparatus of claim 12, wherein:

the wireless communication device has an amplifier circuit,

the amplifier circuit amplifying the radiation before the radiation is received by the second coupling element when the wireless communication device is operational, the first coupling element redirects radiation, the amplifier circuit amplifies the radiation and the second coupling element redirects radiation when the wireless device is operational such that a specific absorption rate (SAR) of the wireless communication device is reduced without substantially adversely affecting a total radiation power (TRP) of the wireless communication device.

18. An apparatus comprising:

a wireless communication device having an antenna, a first coupling element, a second coupling element and an amplifier circuit,

the first coupling element redirecting radiation from the antenna to the second coupling element when the wireless communication device is operational, the second coupling element redirecting radiation away from a user of the wireless communication device when the wireless communication device is operational,

the amplifier circuit amplifying the radiation before the radiation is received by the second coupling element when the wireless communication device is operational, an amplitude of the radiation from the antenna at a first time is greater than an amplitude of the radiation from the antenna at a second time after the first time,

the wireless communication device configured to reduce the amplitude of the radiation at the first time to the amplitude of the radiation at the second time in response to a signal from a base station in communication with the wireless communication device,

an amplitude of the radiation from the second coupling element at the second time being substantially similar to

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an amplitude of the radiation from the second coupling element at the first time is the amplifier circuit was not operational.

19. An apparatus, comprising:

a wireless communication device having an antenna, a first coupling element, a second coupling element and an amplifier circuit,

the first coupling element redirecting radiation from the antenna to the second coupling element when the wireless communication device is operational, the second coupling element redirecting radiation away from a user of the wireless communication device when the wireless communication device is operational,

the amplifier circuit amplifying the radiation before the radiation is received by the second coupling element when the wireless communication device is operational, an amplitude of the radiation from the antenna at a first time is greater than an amplitude of the radiation from the antenna at a second time after the first time,

the wireless communication device configured to reduce the amplitude of the radiation at the first time to the amplitude of the radiation at the second time in response to a signal from a base station in communication with the wireless communication device,

a specific absorption rate (SAR) of the wireless communication device at the second time is less than a SAR of the wireless communication device at the first time.

20. The apparatus of claim 19, wherein:

the specific absorption rate (SAR) of the wireless communication device at the second time is less than the SAR of the wireless communication device at the first time without substantially adversely affecting a total radiation power (TRP) of the wireless communication device at the first time and a TRP of the wireless communication device at the second time.

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